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REMARKS

Applicants have carefully reviewed this Application in light of the Final Office Action mailed May 30, 2005. Claims 1-6, 8, 15 and 25 were previously cancelled without prejudice or disclaimer. Claims 7, 9-14, 16-24 and 26-30 are pending in this Application. Claims 7, 9-14, 16-24, and 26-30 stand rejected under 35 U.S.C. § 112, first paragraph and 35 U.S.C. § 103. Claims 7 and 17 have been amended to further define various features of Applicants' invention. Applicants respectfully request reconsideration and favorable action in this case.

Objections under 35 U.S.C. § 132(a)

The Examiner continues to object to the amendment filed February 9, 2005, under 35 U.S.C. § 132(a) because the Examiner alleges that the amendments introduced new matter into the disclosure. Applicants respectfully submit that the continued objection under 35 U.S.C. § 132(a) is in error. Specifically, the M.P.E.P. states that:

> If new subject matter is added to the *disclosure*, whether it be in the abstract, the specification, or the drawings, the examiner should object to the introduction of new matter under 35 U.S.C. 132 or 151 as appropriate, and require applicant to cancel the new matter. If new matter is added to the *claims*, the examiner should reject the claims under 35 U.S.C. 112, first paragraph – written description requirement. *In re Rasumssen*, 650 F.2d 1212, 211 USPQ 323 (CCPA 1981).

M.P.E.P. § 2163.06(I) (emphasis added). Applicants have not made any substantive amendments to the disclosure and, therefore, submit that the objection under 35 U.S.C. § 132(a) is improper. Thus, Applicants request that the Examiner withdraw the objection under 35 U.S.C. § 132(a).

Assuming, *arguendo*, that the objection under 35 U.S.C. § 132(a) is proper, which Applicants do not concede, Applicants continue to assert that no new matter has been added and that the Examiner has not established a *prima facie* case of new matter. In the Final Office Action, the Examiner continues to argue, by repeating, almost word for word the objection in the Office Action dated December 19, 2005, that the amendments to the claims are not supported by the original disclosure. Specifically, the Examiner states that added material not supported by the original disclosure includes the phrases "light is transmitted ... through the opening through the thin film and onto the wafer," as recited in Claims 1, 17 and 26, "wherein a portion of the transmitted (or projected) light is diffracted by the photomask

opening and passes through the thin film at the angle of incidence greater than zero, the transmission of such portion of light passing through the thin film at the angle of incidence greater than zero being maximized due to the optical thickness of the thin film produces an increased resolution of the projected image on the wafer," as recited in Claims 7 and 26, and "light transmitted ... through the opening in the photomask, through the thin film and onto the wafer ... a portion of the transmitted light is diffracted by the photomask opening and passes through the thin film as off-axis light the approximate 99% transmission of such off-axis light produces an increased resolution of the image of the opening projected onto the wafer," as recited in Claim 17. To support the objection, the Examiner provides the following remarks:

> The specification fails to teach that the transmitted light passes through the photomask, then through the thin film and then to the wafer, and fails to teach the light diffracted by the photomask or the projected image generated from the photomask will pass the thin film again and a diffracted portion of the light passes through at an incident angle greater than zero is maximized due to the optical thickness of the thin film. The specification also fails to positive support for the diffracted light from the photomask passes through the thin film as off-axis light and 99% of the off-axis light increase the resolution of the image. The specification explicitly teaches that the pellicle film is on the photomask wherein the light will incident on the pellicle first before it been diffracted by the photomask as demonstrated by Figure 3 of the instant application.

(Office Action, Pages 2-3).

Applicants again reiterate that while Figure 3 of the Application depicts that pellicle 50 is mounted on photomask 54 and covers patterned layer 53, neither Figure 3 or any other portion of the specification "explicitly teaches" that light must be incident upon the pellicle before being diffracted by photomask 54, as alleged by the Examiner. Figure 3 does not indicate the placement of a light source with respect to photomask 54 or pellicle 50. Additionally, Figure 3 does not mandate a certain orientation of photomask 54 in a lithography system (e.g., whether patterned layer 53 of photomask 54 is facing the light source or the imaging lens). Thus, Figure 3 does not even implicitly, let alone "explicitly," teach that light must be incident first upon pellicle 50 before being diffracted by photomask 54, and the Examiner has yet to present any support for the continued assertions that light cannot be incident upon a photomask prior to passing through a pellicle, as disclosed by the specification and recited by the claims.

In further support of the objection, the Examiner remarks:

> The applicant is respectfully noted, although the specification loosely discloses that the pellicle may be placed between the photomask and an imaging lens, (specification page 10 lines 15-17), this phrase does not give the support for "wherein a portion of the transmitted (or projected) light is diffracted by the photomask opening and passes through the thin film at the angle of incidence greater than zero, the transmission of such portion of light passing through the thin film at the angle of incidence greater than zero being maximize due to the optical thickness of the thin film produces an increased resolution of the projected image on the wafer" and/or "light transmitted ... through opening in the photomask through the thin film onto the wafer ... a portion of the transmitted light is diffracted by the photomask opening and passes through the thin film as off-axis light the approximate 99% transmission of such off-axis light produces an increased resolution of the image of the opening projected onto the wafer" as claimed in the claims.
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> ... [T]he specification fails to give an explicitly relationship between the pellicle, the photomask, the imaging lens and the wafer. ...
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> Furthermore, the applicant is also respectfully noted that in the same paragraph of the specification (page 10) there is an explicitly teaching of having the pellicle "covers" the photomask for protecting it from dust. If one reads the paragraph in page 10 of the specification with the explicitly disclosure of the pellicle being formed on the photomask as shown in Figure 3, one would not be able to deduce that the diffracted light from the photomask is capable of being transmitted through the pellicle and the non-zero incident of the diffracted light on the pellicle will be maximized and the light diffracted from the photomask will be off-axis light passes through the pellicle with 99% of the off-axis light increases the resolution of image".

(Office Action, Pages 3-4).

Applicants again reiterate that the specification contains more than ample support for the claims, adequately describes the relationship between the pellicle, the photomask, the imaging lens, and the wafer, and more than "loosely" discloses that the pellicle may be placed between the photomask and an imaging lens.

Applicants respectfully submit that the Examiner's continued objection is improper because the Examiner has not fully considered Applicants' citations to the specification and previous arguments based on the cited portions of the specification. *See* M.P.E.P. § 2163(II) ("Upon reply by applicant, before repeating any rejection under 35 U.S.C. 112, para. 1, for lack of written description, review the basis for the rejection in view of the record as a whole, including amendments, arguments, and any evidence submitted by applicant. . . . If the record

still does not demonstrate that the written description is adequate to support the claims(s), repeat the rejection under 35 U.S.C. 112, para. 1, fully respond to applicant's rebuttal arguments, and properly treat any further showings submitted by applicant in the reply."); *In re Alton*, 76 F.3d 1168, 1176, 37 USPQ2d 1578, 1584 (Fed. Cir. 1996). Instead, the Examiner has reiterated, almost word for word, the previous objections and only cursorily responded to the arguments presented in support of the portions of the specification cited by Applicants. For example, in response to Applicants' arguments that the specification supports the claimed spatial relationship among the pellicle, the photomask and the wafer, the Examiner merely states:

> Out of all citations of different portions of the specification, the applicant fails to provide just one single paragraph which explicitly states, "light is transmitted at the particular wavelength through opening in the photomask, through the thin film and onto wafer to project an image of the photomask opening onto the wafer, wherein a portion of the transmitted light is diffracted by the photomask opening and passes through the thin film at the angle of incidence greater than zero" as recited in Claims 7, and 17 or "projecting the radiant energy through opening in the photomask, through the thin film and onto wafer to form an image of the photomask opening in the wafer, wherein a portion of the projected light is diffracted by the photomask opening and passes through the thin film at the angle of incidence greater than zero" as recited in claim 26. The piece meals presentation fails to provide the explicit features recited in the claims.

(Office Action, Pages 12-13).

Applicants are unaware of any statute, regulation or portion of the M.P.E.P. that requires the Applicants to "provide ... one paragraph which explicitly states" the claimed elements. In fact, "[t]o comply with the written description requirement of 35 U.S.C. § 112, para. 1 ..., each claim limitation must be expressly, *implicitly*, or *inherently* supported in the originally filed disclosure." M.P.E.P. § 2163(II)(A)(3)(b) (emphasis added); *see also*, Hyatt *v. Boone*, 146 F.3d 1348, 1353, 47 U.S.P.Q.2d 1128, 1131 (Fed. Cir. 1998); *In re Robins*, 429 F.2d 452, 456-57, 166 U.S.P.Q. 552, 555 (C.C.P.A. 1970). The language quoted above does not provide that each claim limitation must be "explicitly" stated within "one paragraph" of the disclosure, but instead that claim limitations must be expressly, implicitly, or inherently supported in the disclosure. Applicants have repeatedly shown during the prosecution of this Application that the specification, taken as a whole, supports the claimed elements. M.P.E.P. § 2163(II)(A)(2) ("Prior to determining whether the disclosure satisfies the written

description requirement for the claimed subject matter, the examiner should review the claims and the *entire specification*, including the specific embodiments, figures, and sequence listings, to understand how applicant provides support for the various features of the claimed invention.") (emphasis added).

However, assuming, *arguendo*, that the specification language cited by the Applicants does not provide express support for the claimed elements, for which the Examiner has provided no arguments, the specification implicitly and inherently supports the claimed elements. *See* M.P.E.P. § 2163.07(a) ("By disclosing in a patent application a device that inherently performs a function or has a property . . . a patent application necessarily discloses that function . . . even though it says nothing explicit concerning it [and the] application may later be amended to recite the function . . . without introducing prohibited new matter"); *In re Smythe*, 480 F.2d 1376, 178 USPQ 279 (CCPA 1973); *In re Reynolds*, 443 F.2d 384, 170 USPQ 84 (CCPA 1971).

As repeatedly noted during the prosecution of this Application, the specification contains numerous statements regarding the spatial relationship among the pellicle, the photomask, the imaging lens and the wafer. For example, Figures 2A and 2B depict incident light 12 (32) striking mask 14 (34), where incident light 12 (32) is diffracted and a portion is captured by lens 20 (40). Light captured by lens 20 (40) is then projected onto a wafer. (Specification, Page 3, line 24 - Page 4, line 9, and Page 4, line 21 - Page 5, line 12). In accordance with the present invention, a pellicle including a frame and a thin film is coupled to a photomask. (Specification, Page 6, lines 22-27). The photomask assembly including the pellicle and the photomask can be spatially oriented such that the pellicle is placed between the light source and the photomask, or between the photomask and the imaging lens, or both. (Specification, Page 10, lines 15-17; Page 13, lines 11-17). Thus, if, as expressly disclosed by the specification:

> (i) incident light may strike a mask, be diffracted by the photomask, be captured by a lens, and projected onto a wafer; and
>
> (ii) a pellicle and a photomask may be oriented such that the pellicle is placed between the photomask and the imaging lens;

it logically follows that light may be transmitted through the photomask, through the thin film pellicle and onto wafer to project an image of the photomask opening onto the wafer as

claimed in Claims 7 and 17. Accordingly, Applicants submit that the portions of the specification cited above expressly, and at the very least, implicitly and inherently, support the recited elements of the Claims. Moreover, Examiner's concession that "the specification loosely discloses that the pellicle may be placed between the photomask and an imaging lens" is sufficient under applicable law and the M.P.E.P.

Additionally, there is no requirement that "[i]nformation which is well known in the art . . . be described in detail in the specification." M.P.E.P. § 2163(II)(A)(2); *see also Hybritech, Inc. v. Monoclonal Antibodies, Inc.*, 802 F.2d 1367, 1379-80, 231 USPQ 81, 90 (Fed. Cir. 1986). Applicants would like to bring to the Examiner's attention excerpts from two reference books available at the time that the Application was filed, which disclose information about the photolithographic process and the orientation of a photomask in a lithography system. First, "The Handbook of Microlithography, Micromachining, and Microfabrication" discloses that a photomask is placed in a lithography system such that the patterned layer (see black spaced marks on the Reticle) is facing the wafer. (*See* Exhibit A, Page 72). The light from a light source (not expressly shown) travels through a Condensor Lens, through the Reticle, is captured by a Projection Lens (e.g., imaging lens) and projected onto the Wafer. (*See* Exhibit A, Page 72). Second, "Silicon Processing for the VLSI Era, Volume 1 – Process Technology" discloses that a pellicle is placed in a lithography system between the photomask and the imaging lens. (*See* Exhibit B, Page 488). The pellicle is typically placed on the chrome side of the mask (e.g., the patterned side) to protect the photomask from particulates and other contaminants. (*See* Exhibit B, Page 487). Thus, as shown by these two reference books, it is well known that in a lithographic process a photomask is placed in a lithography system such that the patterned layer faces the wafer. A pellicle is placed on the photomask to protect the patterned layer and light travels through the photomask, is diffracted by the openings in the patterned layer and the diffracted light then passes through the pellicle.

Furthermore, "[t]he examiner has the initial burden of presenting evidence or reasoning to explain why persons skilled in the art would not recognize in the original disclosure a description of the invention defined by the claims." *See In re Wertheim*, 541 F.2d 257, 263, 191 U.S.P.Q. 90, 97 (C.C.P.A. 1976); M.P.E.P. § 2163(II)(A)(3)(b). However, the Examiner has failed to provide proof (*e.g.*, references of record) to support the

conclusion that the claim amendments objected to as new matter are not permitted because persons skilled in the art would not recognize in the specification a description of the invention defined by the claims. If the Examiner is relying upon personal knowledge to support such a conclusion, no affidavit has been provided in accordance with the M.P.E.P. *See* M.P.E.P § 2144.03 (setting forth the requirements of reliance of common knowledge in the art).

To further illustrate the error in the Examiner's continued assertion that the specification does not support the recited spatial relationship among the recited claim elements, Applicants note that in one portion of the Office Action, the Examiner states that the placement of the pellicle "after" the photomask "totally defeats the purpose of using pellicle to cover photomask for protecting it." (Office Action, Page 13). Applicants are confused by this argument, as Examiner fails to explain how the mere act of "flipping over" a photomask assembly including a pellicle such that the patterned layer is facing the wafer somehow renders the pellicle completely useless to protect the photomask.

In yet further support of the Section 132 objection, the Examiner remarks:

> [T]he specification fails to teach that the thickness of the pellicle is designed to maximized the diffracted light from the photomask toward the wafer. A simple language of placing the pellicle between the photomask and the imaging lens (without explicitly states the location of the imaging lens to the least) WILL NOT be enough to support the "maximization of diffracted light portion from the photomask trough the pellicle to the wafer" or "99% of the transmission of the off-axis light produces an increased resolution of image".

(Office Action, Pages 3-4).

To the contrary, the specification provides more than ample support for these elements of the claimed invention. For example, as previously argued by the Applicants without response by the Examiner, the specification contains the following passages which more than adequately support the claims:

- "In accordance with another embodiment of the present invention, a pellicle includes a thin film having an optical thickness greater than a design thickness that produces a transmission maxima for normal incidence light at a desired exposure wavelength. The optical thickness preferably is optimized for transmission of off-axis incident light at a desired angle." (Page 6, lines 15-21).
- "The pellicle includes a frame coupled to the photomask and a thin film that

transmits approximately ninety-nine percent of off-axis light at an exposure wavelength." (Page 6, lines 24-27).

- "The optical thickness is optimized for transmission of off-axis incident light through the thin film." (Page 7, lines 1-3)
- "Another important technical advantage of certain embodiments of the present invention includes a pellicle coated with an anti-reflective material that creates a higher differential between on-axis and off-axis light. By increasing the amount of off-axis light transmitted through the pellicle, the intensity of the high order components containing spatial information for an image may also be increased relative to the low order components containing no spatial information. The increased intensity of the high order components allows for better control of the line edges of fine device features and therefore, increases the resolution of an associated photolithography system." (Page 7, lines 23-35).
- "The optical characteristics of the pellicle can significantly affect the performance of the photolithography system, including the amount of off-axis light transmitted through the photomask. In a particular embodiment, the pellicle of the present invention increases the transmission of off-axis light through an associated photomask by having an optical thickness that is greater than a design thickness for an exposure wavelength." (Page 10, lines 17-25).
- "As shown by the graph, if film 51 has a design thickness of 845 nm, transmission of incident light drops from approximately ninety-nine percent (99%) at a zero degree angle of diffraction from patterned layer 53 of photomask 54 to approximately ninety-four percent (94%) at a twenty degree angle of diffraction. Since transmission at a given wavelength is directly related to the thickness of film 51, a thicker film may increase the amount of off-axis light captured at the given wavelength." (Page 13, lines 2-10).
- "In one embodiment, off-axis transmission of light may be increased by designing the optical thickness of film 51 to be less than or equal to one-quarter of the exposure wavelength greater than a design thickness that produces a transmission maxima at the exposure wavelength." (Page 13, line 31 - Page 14, line 1).
- "The increased optical thickness produces a transmission maxima at a wavelength slightly higher, e.g., approximately one to twenty nanometers, than the exposure wavelength for the photolithography system. Therefore, by increasing the optical thickness, film 51 will be optimized for transmission of light at a desired angle that is greater than normal incidence." (Page 14, lines 8-15).
- "As the physical thickness increases, a higher differential between normal incidence, on-axis transmission and higher angle, off-axis transmission occurs, which optimizes the transmission of light for multiple angles of incidence. By controlling the physical thickness of the pellicle film, the placement of the transmission peaks with respect to wavelength and angle of incidence may be achieved. Furthermore, if a transmission maxima for larger angles of incidence occurs at the exposure wavelength of the photolithography system, the system may capture the spatial information contained in the higher order peaks and create

a high resolution image of the openings on the photomask." (Page 14, line 34 - Page 15, line 11).

Applicants submit that the portions of the specification cited above, when read together, expressly, and at the very least, implicitly and inherently, support the recited elements of the Claims.

In addition, the Examiner has stated in the Office Action that the specification fails to support "the light being diffracted by the photomask and incident on the pellicle at an angle greater than zero." (Office Action, Page 13-14). As noted above by the Applicants, the specification provides more than ample support for light being diffracted by a photomask and the diffracted light being incident on a pellicle. Also, Applicants point to the above list of passages from the specification which support "off-axis" incidence on a pellicle, or in other words, incidence at an angle greater than zero. As indicated in the M.P.E.P., there is no requirement that the terms used in the claims be identical to the terms used in the disclosure. M.P.E.P. § 2163.02.

In still further support of the Section 132 rejection, the Examiner remarks, "[t]he imaging lens is not even in the claims and is not disclosed in the specification either." (Office Action, Page 4). As previously argued by the Applicants, without response by the Examiner, an imaging lens is disclosed numerous times in the specification. For example, the specification states:

- "In a photolithography system, an *imaging lens* should capture the zero order peak and at least one higher order peak to create an accurate image on a wafer since the zero order peak contains the intensity of the image and the higher order peaks contain the image's spatial information." (Page 2, lines 24-29) (emphasis added).
- "The relationship between the resolution of a photolithography system, e.g., the minimum feature size of an image, and the numerical aperture of the *imaging lens* is described by Rayleigh's formula, ..." (Page 2, line 34 - Page 3, line 2) (emphasis added).
- "*Lens 20* may capture zero order peak 16 and project the image features present in zero order peak 16 onto a wafer (not expressly shown). *Lens 20* may also project spatial information contained in first order peaks 17 and 18 onto the wafer if the numerical aperture of *lens 20* is sufficiently large enough to capture light having angles of diffraction larger than zero degrees." (Page 4, lines 3-9) (emphasis added).
- "... *lens 40* may capture zero order peak 36 and first order peak 37, and project the image features present in zero order peak 36 and first order peak 37 onto a

wafer (not expressly shown)." (Page 4, line 35 - Page 5, line 3) (emphasis added).

- "The pellicle may be placed between the light source and the photomask, or between the photomask and the *imaging lens*, or both." (Page 10, lines 15-17) (emphasis added).
- "In one embodiment, pellicle 50 may be located between photomask 54 and an *imaging lens* (not expressly shown) of a photolithography system. A radiant energy source (not expressly shown) emits a wavelength of light toward photomask 54 and the incident light passes through the transparent openings formed by patterned layer 53 of photomask 54. The incident light on photomask 54 diffracts beams that create a Fraunhofer diffraction pattern. Each peak of the Fraunhofer pattern corresponds to the openings' Fourier expansion series terms. If light having large diffraction angles is collected by the *imaging lens*, the projected image will consist of an increased amount of Fourier expansion series terms." (Page 13, lines 11-23) (emphasis added).

Furthermore, Applicants are unaware of any requirement of applicable law, regulations, rules, or provision of the M.P.E.P. that would require Applicants to claim an imaging lens in order for the claims to be allowable. While the specification contemplates that light emerging from a photomask assembly is captured by an imaging lens and then projected onto a wafer, Applicants need not claim every detail which enables the present invention. *See e.g.*, M.P.E.P. § 2164.08(c) (stating that a feature which is taught as critical in a specification must be recited in the claims, while features which are merely preferred are not to be considered critical and need not be claimed). For example, while Applicants set forth in the specification the types of materials that may be used for various components of the present invention, these materials need not be claimed. Similarly, while an imaging lens is useful to project light emerging from a pellicle film onto a wafer, such imaging lens need not be claimed any more than Applicants need to claim the type of medium (for example, air or a vacuum) through which transmitted light travels before reaching the wafer.

In additional support of the objection, the Examiner remarks:

> Furthermore, since the pellicle has only specific transmission peaks at specific wavelength and specific angles of incidence, to simply placing the pellicle between the photomask and the imaging lens will not be able to meet the sophisticated condition to produce the maximum off-axis transmission for the diffracted light as claimed in the claims.

(Office Action, Page 4).

As noted and argued by the Applicants in their previous response, to which the

Examiner has not responded, Applicants do not understand the argument being made by the Examiner and respectfully request that the Examiner clarify this argument. Applicants assert that the results set forth in the specification were not obtained by "simply placing the pellicle between the photomask and the imaging lens" but rather were a result of practicing the claimed systems and methods. Applicants respectfully submit that the methods and systems claimed by the Applicants, read in light of the specification, are sufficient to "meet the sophisticated condition to produce the maximum of off-axis transmission for the diffracted light as claimed in the claims" given that the specification details that the Applicants observed such results by practicing the claimed methods and systems. (*See* Figure 5 and Specification, Page 18, lines 1-14). Applicants further submit that the Examiner has failed to provide proof (*e.g.*, references of record) to support the conclusion that placing the pellicle between the photomask and the imaging lens is not operable to produce the maximum off-axis transmission for the diffracted light as claimed in the claims. If the Examiner is relying upon personal knowledge to support such a conclusion, no affidavit has been provided in accordance with the M.P.E.P. *See* M.P.E.P. § 2144.03 (setting forth the requirements of reliance of common knowledge in the art).

Moreover, Applicants object to Examiner's allegation that "Applicant's own admission that the specification needs to 'read together with the claims' to make these features explicitly [sic] is an admission that the specification simply fails to give such explicitly [sic] teachings, since the portions of the claims that the applicant referred to are added new matters themselves." (Office Action, Page 13). First, while the specification does provide explicit support for the amended claim language, Applicants respond to Examiner's continued insistence that the specification does not "explicitly" teach the subject matter recited in the claims by reiterating their argument above that the specification may implicitly or inherently teach the subject matter recited in the claims. *See* M.P.E.P. § 2163.07(a). Applicants also submit that the statement in their previous response that the "specification [should be] read together with the claims" was not an admission that the claims added new matter, but simply a statement regarding one of the most basic tenets of United States patent law that in order to properly construe claim language, claims (whether in their original form or as amended during prosecution) must be read together with the specification. M.P.E.P. § 2111 ("During patent examination, the pending claims must be given their broadest

reasonable interpretation consistent with the specification."); *see e.g., In re* Hyatt, 211 F.3d 1367, 1372, 54 USPQ2d 1664, 1667 (Fed. Cir. 2000). Accordingly, the Applicants respectfully submit that they were not making an admission that they added new matter, but merely pointing out that the specification, when read in conjunction with the amended claims, provides more than ample support for the claim amendments.

For the reasons set forth above, Applicants respectfully submit that all of the amendments made in the response filed on February 9, 2005 do not add new matter and are fully supported by Applicants' specification. Applicants respectfully request that the Examiner reconsider and withdraw the objections to the claims.

Rejections under 35 U.S.C. § 112

Claims 7, 9-14, 16-24, and 26-30 stand rejected under 35 U.S.C. § 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the art that the inventors, at the time the application was filed, had possession of the claimed invention.

Specifically, the Examiner bases this rejection on allegedly newly added matter in the amendments filed on February 9, 2005. For the reasons described above in the arguments related to the Examiner's objection under 35 U.S.C. § 132(a), no new matter has been added and the amendments are fully supported by Applicants' specification. Applicants respectfully request that the Examiner reconsider and withdraw the rejections to Claims 7, 9-14, 16-24 and 26-30.

Claims 7, 9-14, 16-24, and 26-30 additionally stand rejected under 35 U.S.C. § 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. Specifically, the Examiner states that the phrase "the transmission of such portion of light . . . produce an increased resolution of the projected image on the wafer," as recited in Claim 7 and the phrase "projection of the diffracted portion of light . . . increase the resolution of the image," as recited in Claim 26 are not enabled by the disclosure because "[t]he resolution of a projected image therefore is implicitly defined at least in part by the size of spatial information of the photomask, but not by the projection of certain portion of the light." (Office Action, Page 5). In an Office

Action dated December 10, 2004, the Examiner stated that the phrase "the resolution of the image . . . being defined at least in part by the projected spatial information," as recited in independent Claims 7, 17 and 26, was "confusing and indefinite since it is not clear what is this spatial information and how can the resolution be defined by the spatial information." (Office Action, Page 5). These two statements are completely inconsistent and the Examiner now uses language deleted from Applicants' claims to reject independent Claims 7 and 26.

Applicants reiterate their previous response to this rejection, which heretofore has not been responded to by the Examiner. Specifically, the Applicants argued that, assuming that Examiner's assertion that the resolution of an image is defined at least by the size or spatial information of the opening of a photomask, such assertion only serves to confirm that Claims 7 and 26 are enabled by the specification. As taught by the specification, "[w]hen incident light encounters [a photomask] slit, an illumination intensity profile, known as a Fraunhofer diffraction pattern, results that is a function of the slit width and the wavelength of the light." (Specification, Page 2, lines 16-19). Further "[i]n a photo lithography system, an imaging lens should capture the zero order peak and at least one higher order peak [of the Fraunhofer diffraction pattern] to create an accurate image on a wafer since the zero order peak contains the intensity of the image and the *higher order peaks contain the image's spatial information.*" (Specification, Page 2, lines 24-29) (emphasis added). Hence, the spatial information of the photomask is translated into light which includes image intensity *and* image spatial information. The specification further states that when the higher order components of the Fraunhofer diffraction pattern that contain spatial information are transmitted through the thin film and onto a wafer, a high resolution image may be projected onto the wafer. (Specification, Pages 14-15). Hence, while resolution of an image may be determined at least in part by photomask dimensions as noted by the Examiner, resolution may also be determined by portions of the light projected through a photomask. Moreover, Applicants submit the Examiner has failed to provide proof (*e.g.*, references of record) to support the conclusion that the resolution of a projected image cannot be defined by the projection of certain portion of the light. If the Examiner is relying upon personal knowledge to support such a conclusion, no affidavit has been provided in accordance with the M.P.E.P. *See* M.P.E.P § 2144.03 (setting forth the requirements of reliance of common knowledge in

the art). Applicants, therefore, submit that independent Claims 7 and 26 meet the requirements of section 112, first paragraph.

The Examiner also rejected Claims 7, 17 and 26 under 35 U.S.C. § 112, first paragraph stating that the structure shown in Figure 3, "the light passes through the thin film first then to the photomask. The light diffracted by the photomask will not pass through the film again..." Yet again, the Examiner assumes without any basis, explanation or rationale that in the structure shown in Figure 3, light must invariably be incident upon pellicle 50 before passing to photomask 54, despite the fact that Examiner has not yet provided any grounds for such assumption and the fact that such assumption is refuted by the plain language of the specification, as detailed above. As explicitly taught by the specification, the pellicle may be located between the photomask and the imaging lens used to project any image on the wafer. (Specification, Page 10, lines 15-17, Page 13, lines 11-23). Therefore, diffracted light can pass through the thin film, and claims 7, 17 and 26 meet the requirements of section 112, first paragraph.

Finally, the Examiner rejected Claim 17 under 35 U.S.C. § 112, first paragraph because "[t]he specification only enables the off-axis light at certain degrees of incidence to have transmission approximates 99% of the light but not to all of the off-axis lights or not to any off-axis light at any incident angle." (Office Action, Page 4). Claim 17 recites the limitation of an "amorphous fluoropolymer thin film operable to transmit approximately ninety-nine percent (99%) of off-axis light at a particular wavelength." Applicants reiterate the argument from the Response dated October 17, 2005 that the claim does not recite transmission of all off-axis light at any incident angle, rather the claim recites transmission of a significant percentage of off-axis light at a certain wavelength. Additionally, the claim is supported by the specification. (*See* Specification, Pages 14-15 and Figure 5). In the Office Action, the Examiner does not refute Applicant's argument, but merely restates Examiner's earlier argument. Applicants, therefore, submit that independent Claim 17 meet the requirements of section 112, first paragraph.

Because independent Claims 7, 17 and 26 meet the requirements of section 112, first paragraph, Applicants respectfully request that the Examiner reconsider and withdraw the rejections to Claims 7, 9-14, 16-24 and 26-30.

Claim Objections

Claims 9, 12, 19, 21 and 29 were objected to by the Examiner because of informalities. Specifically, the Examiner states:

> it is not understandable how the thin film having thickness that gives peak transmission for **off-axis** or **non-normal incident light** but is able to give peak transmission that is *1 nanometer* above the "particular wave length." It is impossible to have this kind of accuracy for light having wave length differing in one nanometer to give so different transmission property.

(Office Action, Page 6) (emphasis in original).

In their previous response, Applicants stated that they were unaware of any provision under applicable law, regulations or the M.P.E.P. that provides the Examiner with authority or discretion to object to Claims 9, 12, 19, 21 and 29 for the reasons stated in the Office Action. In the Office Action, the Examiner responds to Applicants' statement as follows:

> In response to applicant's challenge of examiner's authority in objecting claims 9, 12, 19, 21 and 29 for the accuracy and even possibility of claimed subject matters, the applicant is respectfully notes that 35 USC 101, and 112 gives the examiner authority to question the enablement of the claimed subject matters.

(Office Action, Page 14).

Applicants recognize that the Examiner has the authority to reject to claims under 35 U.S.C. §§ 101 and 112 if such claims are not enabled by the specification. However, the Examiner has not made a rejection under either Section 101 or 112, but has instead objected to the claims because of informalities. Applicants respectfully request that if the Examiner desires to maintain her opposition to Claims 9, 12, 19, 21 and 29 based on alleged non-enablement, that the Examiner maintain the opposition as a rejection under Sections 101 and/or 112 and not as an objection.

However, assuming that such a rejection is maintained by the Examiner, the Examiner has yet to state how the specification fails to enable Claims 9, 12, 19, 21 and 29. In making the objections to Claims 9, 12, 19, 21 and 29, the Examiner states:

> If the optical design thickness (T) for making light having the particular wavelength (λ) to have maximum transmission at normal incidence, then the following equation should hold:
>
> $T = (M/2)(\lambda)$ for M being an integer,

The actual optical thickness (T') of the film from claim 7 then should be:

$T' = T + (1/4)(\lambda)$,

In order for the light to have a wavelength within 1 nanometer to 20 nanometer to have a peak or maximum transmission at normal incidence the following equation should hold:

$T' = (K/2)(\lambda + 1 \text{ or } 20 \text{ nm}) = T + (1/4)(\lambda) = (M/2)\lambda + (1/4)(\lambda) = (M/2 + 1/4)\lambda$, K being an integer, or

$(K/2)(\lambda + 1 \text{ or } 20 \text{ nm}) = (M/2 + 1/4)\lambda$

For λ being 248 for instance, the equation becomes

$(K/2)(249) = (M/2 + 1/4)(248)$ or $(K/2)(268) = (M/2 + 1/4)(248)$

or $K = 0.99(M+1/2)$ or $K = 0.92(M + 1/2)$.

(Office Action, Pages 14-15).

However, the Examiner's mathematical analysis is flawed, because the actual optical thickness (T') need not be equal to exactly the design thickness (T) plus one-quarter wavelength. To the contrary, Claim 7 recites "the optical thickness being greater than a design thickness by an amount ***less than or equal to*** approximately one-quarter of the particular wavelength." (emphasis added). Thus, the proper mathematical analysis is as follows:

$T = (M/2)(\lambda)$ for M being an integer,

The actual optical thickness (T') of the film from claim 7 is:

$T' = T + (x)(\lambda)$, where $0 < x \leq 1/4$

Thus, in order for the light to have a wavelength within 1 nanometer to 20 nanometer to have a peak or maximum transmission at normal incidence the following equation should hold:

$T' = (K/2)(\lambda + \Delta\lambda) = T + (x)(\lambda) = (M/2)\lambda + (x)(\lambda) = (M/2 + x)\lambda$, K being an integer, or

$(K/2)(\lambda + \Delta\lambda) = (M/2 + x)\lambda$, where $1\text{nm} \leq \Delta\lambda \leq 20$ nm

Thus, if $\lambda = 248$ nm, the equation becomes:

$(K/2)(248 + \Delta\lambda) = (M/2 + x)(248)$

If $\Delta\lambda = 1$ nm, the equation becomes:

$(K/2)(249) = (M/2 + x)(248)$

or $K = (248/249)(M+2x)$.

In the above equation, K and M can both be integers, and the equation holds. For example, if K = 1 and M = 1, the equation would hold if x = 1/496 or 0.002016. Accordingly, the Examiner's rejection and/or objection is improper.

For at least these reasons, Applicants respectfully request reconsideration and withdrawal of the objections.

Rejections under 35 U.S.C. § 103

Claims 7-14, 16-24, and 26-30 stand rejected by the Examiner under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,742,386 issued to Noriyuki Nose et al. ("*Nose*") in view of U.S. Patent No. 4,657,805 issued to Yasunori Fukumistu et al. ("*Fukumistu*") and U.S. Patent No. 4,966,457 issued to Fuminori Hayano et al ("*Hayano*").

Nose discloses an apparatus for detecting foreign matter on a substrate. The substrate may be a pellicle formed of nitrocellulose. (Col. 1, Lines 44-47). The apparatus monitors the transmittance or the reflectivity of the pellicle and corrects the amount of light projected onto a surface based on the monitored value. (Col. 2, Lines 47-53). In particular, as shown in Figure 1, *Nose* discloses a system for detecting foreign matter a substrate by measuring scattered light caused by such foreign matter along with light that is reflected off of a pellicle located over the substrate. (Fig. 1; Col. 4, Line 22 to Col. 5, Line 49). Corrective measures are performed by varying the intensity of the light beam. (Col. 5, Lines 38-39).

Fukumistu discloses a dust cover comprising a film having a layer of a specific fluoropolymer.

Hayano discloses an apparatus for determining the presence and location of a tiny foreign particle, such as dust, on the surface of a photomask or pellicle substrate. (Col. 1, lines 9-17).

Claim 7 recites a pellicle comprising a "thin film formed to cooperate with a photomask including an opening such that when light is transmitted at the particular wavelength through the opening in the photomask, through the thin film and onto the wafer to project an image of the photomask opening onto the wafer, wherein a portion of the transmitted light is diffracted by the photomask opening and passes through the thin film at the angle of incidence greater than zero, the transmission of such portion of light passing through the thin film at the angle of incidence greater than zero being maximized due to the optical thickness of the thin film produces an increased resolution of the projected image on the wafer."

Claim 17 recites a photolithography system comprising "an amorphous fluoropolymer thin film coupled to the frame, the thin film operable to transmit approximately ninety-nine percent (99%) of off-axis light at a particular wavelength such that during the photolithographic process in which light is transmitted at the particular wavelength through the opening in the photomask, through the thin film and onto the wafer to project an image of the photomask opening onto the wafer, wherein a portion of the transmitted light is diffracted by the photomask opening and passes through the thin film as off-axis light, the approximate 99% transmission of such off-axis light produces an increased resolution of the image of the opening projected onto the wafer."

Claim 26 recites a method for performing photolithography comprising the step of "projecting the radiant energy through the opening in the photomask, through the thin film and onto a wafer to form an image of the photomask opening on the wafer, wherein a portion of the projected light is diffracted by the photomask opening and passes through the thin film at the angle of incidence greater than zero for which the transmission of light through the film is substantially maximized, such that the thin film substantially maximizes projection of the diffracted portion of light onto the wafer due to the optical thickness of the thin film in order to increase the resolution of the image of the photomask opening projected on the wafer."

In response to the rejections under 35 U.S.C. § 103(a), Applicants renew and have restated herein their arguments from their previous response dated March 20, 2006, which have not been responded to by the Examiner. The Examiner has indicated that these arguments have not been considered by the Examiner, stating "[i]n response to applicant's arguments concerning the cited references, the applicant is respectfully reminded that the

features relied upon are not supported by the specification and therefore cannot be relied upon to overcome the rejection." (Office Action, Page 15). Applicants respectfully submit that since the rejections under 35 U.S.C. §§ 132, 112 and 103 are separate and distinct rejections, the fact that features relied upon in overcoming the Section 103 rejections is irrelevant to whether or not the features are supported by the specification. As stated in the M.P.E.P.:

> The primary object of the examination of an application is to determine whether or not the claims are patentable over the prior art. This consideration should not be relegated to a secondary position while undue emphasis is given to nonprior art or "technical" rejections.

M.P.E.P. § 706.03. Accordingly, in order to allow the Applicants to provide a reasoned response to the Section 103 rejections, Applicants respectfully request that Applicants' arguments to the rejections under Section 103 be fully considered and fully responded to by the Examiner, and not be relegated to a secondary position behind the technical rejections under Sections 132 and 112.

As discussed in their prior response, Applicants respectfully submit that the cited references fail to disclose every element of Applicants' invention as amended. Further, there is no motivation, teaching, or suggestion to combine *Nose*, *Hayano* and *Fukumistu*. *Nose*, *Hayano* and *Fukumistu*, alone or in combination, fail to teach at least a "thin film formed to cooperate with a photomask including an opening such that when light is transmitted at the particular wavelength through the opening in the photomask, through the thin film and onto the wafer to project an image of the photomask opening onto the wafer, wherein a portion of the transmitted light is diffracted by the photomask opening and passes through the thin film at the angle of incidence greater than zero, the transmission of such portion of light passing through the thin film at the angle of incidence greater than zero being maximized due to the optical thickness of the thin film produces an increased resolution of the projected image on the wafer," as recited by Claim 7. Additionally, *Nose*, *Hayano* or *Fukumistu* fail to teach a photolithography system including "an amorphous fluoropolymer thin film coupled to the frame, the thin film operable to transmit approximately ninety-nine percent (99%) of off-axis light at a particular wavelength such that during the photolithographic process in which light is transmitted at the particular wavelength through the opening in the photomask, through the

thin film and onto the wafer to project an image of the photomask opening onto the wafer, wherein a portion of the transmitted light is diffracted by the photomask opening and passes through the thin film as off-axis light, the approximate 99% transmission of such off-axis light produces an increased resolution of the image of the opening projected onto the wafer," as recited by Claim 17. Further, *Nose*, *Hayano* or *Fukumistu* fail to teach or suggest "projecting the radiant energy through the opening in the photomask, through the thin film and onto a wafer to form an image of the photomask opening on the wafer, wherein a portion of the projected light is diffracted by the photomask opening and passes through the thin film at the angle of incidence greater than zero for which the transmission of light through the film is substantially maximized, such that the thin film substantially maximizes projection of the diffracted portion of light onto the wafer due to the optical thickness of the thin film in order to increase the resolution of the image of the photomask opening projected on the wafer," as recited by Claim 26.

The Examiner states that "[i]t is . . . implicitly true or obvious modification to one skilled in the art to use light incident at these off-axis incident angles on the thin film pellicle and the light is transmitted by the thin film to the photomask and to expose and transfer the IC pattern on the photomask to the wafer for the benefit of maximizing the intensity of the exposure light to efficiently form the pattern on the wafer." (Office Action, Page 8). The Examiner's rejection, however, fails for at least the following reasons. First, the Examiner's statement with respect to the thin film transmitted off-axis light to the photomask is incorrect. As stated above and specifically recited in Claims 7, 17 and 26, the light is diffracted by an opening in the photomask and the diffracted light passes through the thin film because the thin film is designed to maximize transmission of off-axis (e.g., diffracted) light. Second, *Nose*, *Hayano* and *Fukumistu* do not disclose the recited elements as necessarily present. *Nose*, *Hayano* and *Fukumistu* fail to teach or suggest, either explicitly or implicitly, that a thin film optimized for transmission of off-axis light produces an increased resolution of a projected image on a wafer. In contrast, *Nose* merely discloses that transmittance changes with the incident angle and the pellicle thickness for S-polarized light (Col. 6, Lines 35-37) but is silent on how a pellicle is optimized to transmit off-axis light in order to increase resolution of a projected image. Similarly, *Hayano* merely discloses that a pellicle may have transmission peaks for light incident at angles greater than zero. (Figs. 1 and 2). Only by

reading Applicants' Specification can a person of skill in the art determine how transmission of off-axis light through a thin film is maximized in order to increase the resolution of an image projected on a wafer. (Specification, Pages 7-8 and Pages 14-15). It is improper to use Applicants' Specification as evidence that a claim element is well known in the art. The cited references, therefore, fail to disclose the recited limitations and cannot render obvious Claims 7, 17 and 26.

As another example of the inconsistencies in the Examiner's arguments, the Examiner states that the recited spatial relationship among the recited claim elements "cannot be further examined ... since it is in contradiction to the lithographic process." (Office Action, Page 8). Applicants are also confused by this argument, for numerous reasons. First, Examiner's assertion that the claimed methods and apparatuses are "in contradiction to the lithographic process" is in contradiction to the Examiner's argument (to which the Applicants do not concede) that "Hayano et al teaches explicitly that the pellicle can be placed after the photomask." (Office Action, Page 15). These two arguments advanced by the Examiner are in complete contradiction with each other. Second, the Examiner's argument is further in error given that Applicants explain in the specification that such spatial relationship among photolithographic components is not contrary to lithographic processes. Third, the Examiner has failed to provide proof (*e.g.*, references of record) to support the conclusion that the recited spatial relationship is in contradiction to the photolithographic process. If the Examiner is relying upon personal knowledge, no affidavit has been provided to support such a conclusion. *See* M.P.E.P § 2144.03 (setting forth the requirements of reliance of common knowledge in the art). Finally, Applicants respectfully point the Examiner to Exhibits A and B, attached hereto, which are references showing the operation of a photomask in a lithographic process.

Applicants also renew their arguments to the section 103 rejections in the Response dated October 19, 2005, none of which were refuted or addressed by the Examiner in the Office Action.

Given that Claims 9-14 and 16 depend from Claim 7, Claims 18-24 depend from Claim 17, and Claims 27-30 depend from Claim 26, Applicants respectfully submit that Claims 9-14, 16, 18-24 and 27-30 are allowable. As such, Applicants respectfully request that the Examiner withdraw the rejections and allow Claims 7, 9-14, 16-24 and 26-30.

CONCLUSION

Applicants appreciate the Examiner's careful review of the application. Applicants have now made an earnest effort to place this case in condition for allowance in light of the amendments and remarks set forth above. For the foregoing reasons, Applicants respectfully request reconsideration of the rejections and full allowance of Claims 7, 9-14, 16-24 and 26-30, as amended.

Applicants believe no fees are due at this time, however, the Commissioner is hereby authorized to charge any fees or credit any overpayments to Deposit Account No. 50-2148 of Baker Botts L.L.P. in order to effectuate this filing.

If there are any matters concerning this application that may be cleared up in a telephone conversation, please contact Applicants' attorney at 512.322.2581.

Respectfully submitted,

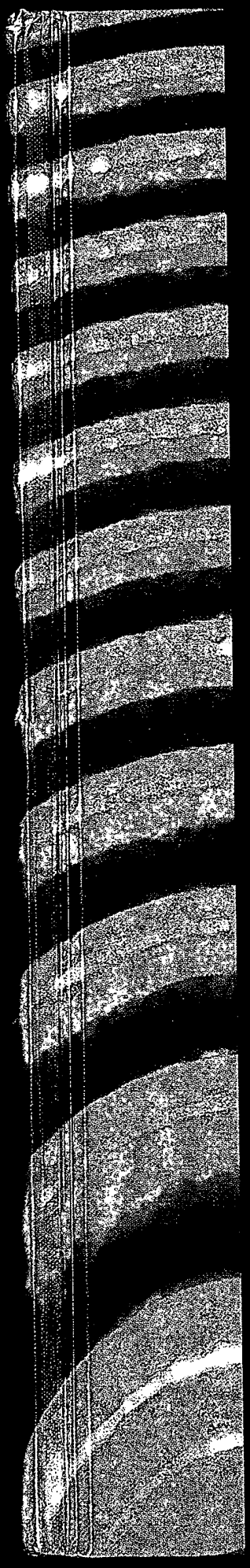
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Microlithography, Micromachining, and Microfabrication

Volume 1: MICROLITHOGRAPHY

Editor
P. RAI-CHOUDHURY

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all involve new complexities related to printing features of different sizes and configurations. These new techniques are all directed towards addressing the effects of diffraction, which limit the depth of focus as resolution is moved to smaller feature sizes.

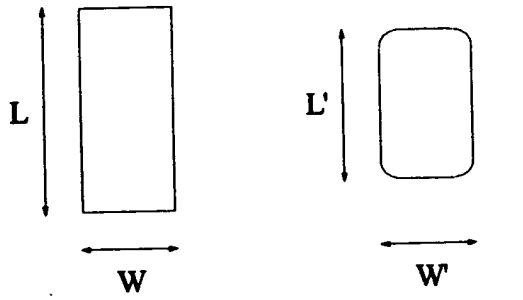


FIG. 1.39 Line shortening, where W = W', but L' < L.

1.2.7 Off-axis illumination

One method, or group of methods, for improving lithography capabilities involves modification of the illumination of the reticle. As discussed earlier, light (coherent) that illuminates a grating is diffracted in very specific directions according to Eq. 1.23. For normally incident light, sufficiently small dimensions result in a situation where all beams except the zeroth order are diffracted outside the entrance pupil of the imaging optics (Fig. 1.40).

A single beam is a plane wave, containing no spatial information; at least two interfering beams are required for pattern imaging. Alternatively, consider the situation in which the illumination is not normally incident. For such off-axis illumination it is possible for the zeroth order light and one first order beam to enter the entrance pupil of the imaging optics. From this simple analysis, one might expect to enhance image contrast by eliminating the illumination with small angles of incidence, since those light rays contribute only to the background light intensity without providing spatial modulation. From Fig. 1.40, one might also expect that off-axis illumination should improve depth of focus even when, for conventional illumination, the first order diffracted beams travel through the entrance pupil, because the angular spread of the light rays in the off-axis situation is less than that for conventional illumination. The benefits of off-axis illumination for enhancing image contrast have been known among optical microscopists. The

concept was introduced to lithographers by Fehrs et. al.[92] and Mack[93] and has since been explored extensively[94-97].

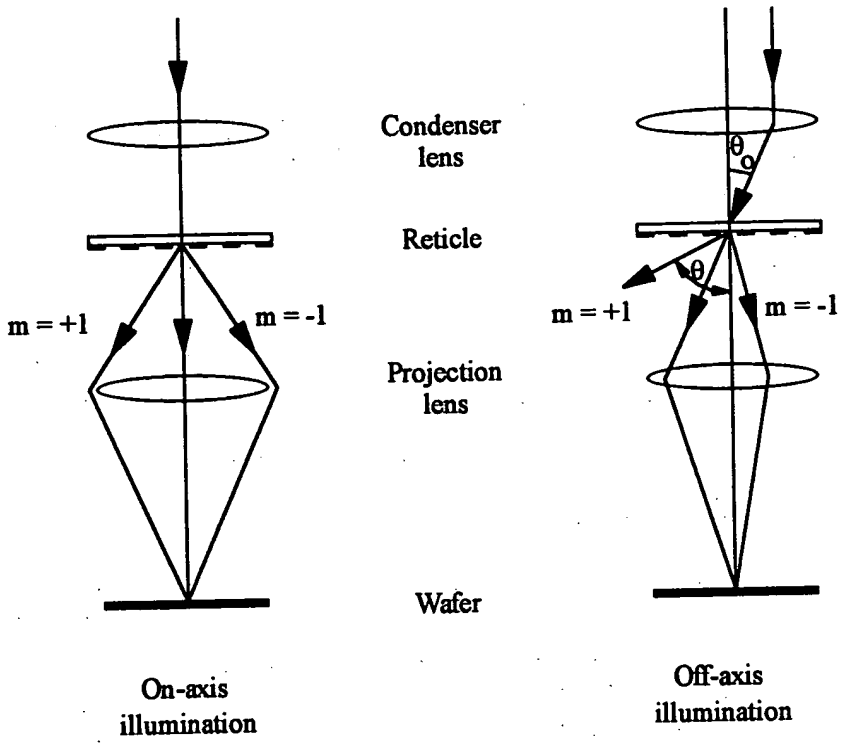
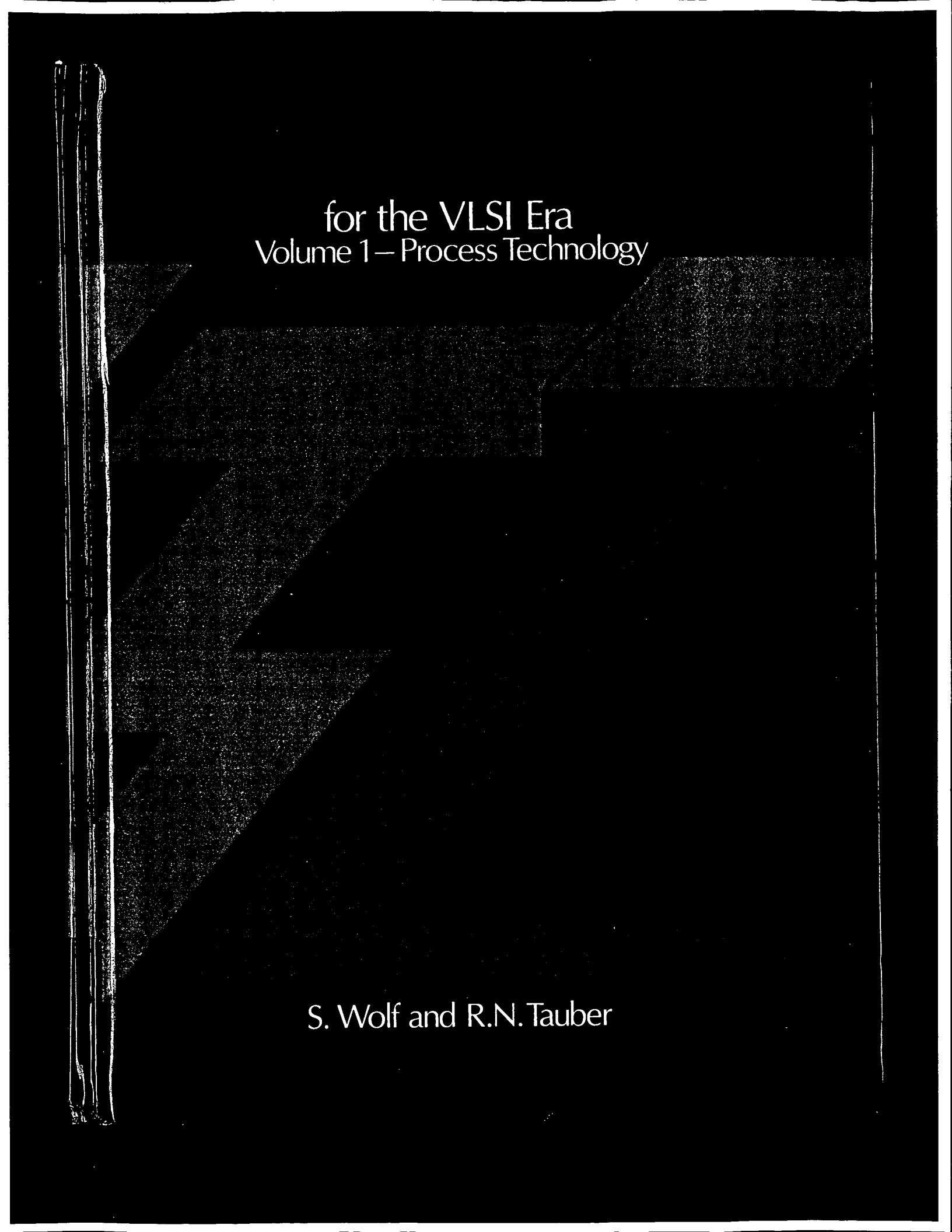


FIG. 1.40 On-axis and off-axis illumination. With off-axis illumination, diffraction orders > 0 will propagate through the projection lens.

If we consider the zero and one first order diffracted rays, the light intensity at the wafer plane is given by

$$I(x,z) = 2a_0^2E_0^2 + 2a_1^2E_0^2\cos\left(\left(\sqrt{1-(\sin\theta_i-\lambda/p)^2}-\cos\theta_i\right)\frac{2\pi z}{p}\right)\cos\left(\frac{2\pi x}{p}\right), \tag{1.81}$$

where a_0 is the fraction of the E-field in the zero order beam, a_1 is the fraction of the E-field in the first order beam, E_0 is the amplitude of the incident E-field, p is the pitch of the grating, x is the lateral distance along the wafer, and z is the



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protecting masks and reticles against such defects is highly desirable. Such a method is available, and it involves the use of pellicles[44,45].

A *pellicle* is a membrane that seals off the mask or reticle surface from airborne particulates and other forms of contamination. The membrane is mounted on a metal frame which is securely attached to the chrome side of the mask, as shown in Fig. 29a. Particles (typically <100 μm) which adhere to the pellicle surface are kept at a distance far enough from the wafer surface that they are not imaged onto the wafer surface (Fig. 29b). The membrane is thin enough to be optically transparent, strong enough to be stretched across a support ring that covers the entire printable area of a mask or reticle, and is sufficiently durable to withstand cleaning and handling. The membrane material must also be stable enough to retain its shape over long periods of time and exposure to 100,000 flashes of UV radiation, and be inexpensive enough to be cost effective. The pellicle material is usually nitrocellulose, with a thickness of 1-15 μm (typically ~2.9 μm).

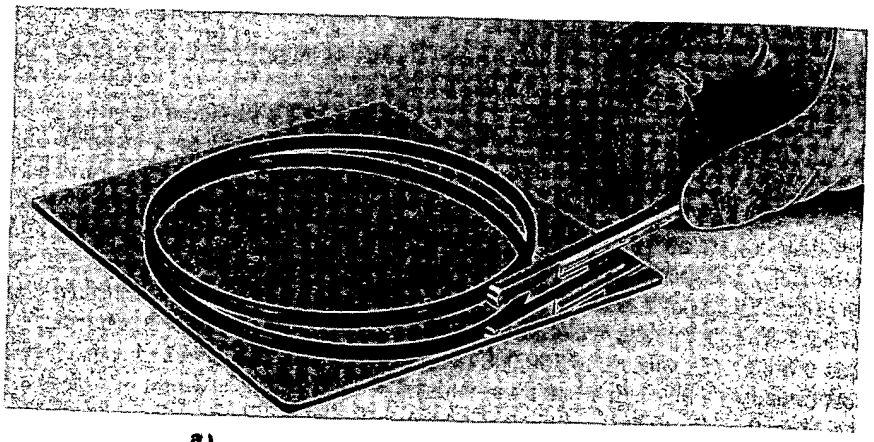
Although it is easy to understand how a pellicle can prevent particles from directly contaminating the chrome surface of a mask, it is useful to elaborate upon the reason why particles which adhere to the pellicle surface may not be imaged onto the wafer surface. From Fig. 29 it can be seen that light directed at the wafer surface will be obscured by particles present both on the back side of the mask and the surface of the pellicle. To insure that a particle on either of these surfaces causes no more than a 10% reduction in the light intensity on the wafer surface, a minimum standoff distance from the mask for a given size of particle can be calculated. This standoff distance, D (in mm), for a particle size (in μm) is calculated from[44]:

$$D = n F P / 280 \qquad (8)$$

where n is the refractive index (1.0 for air, 1.5 for glass), and F is the condenser F-number at the mask or reticle (F = 1 /NA). Figure 29 gives some standoff distances versus particle size, for several values of F-number. For example, the F /4 curve is valid for the optical systems in the Perkin-Elmer 1:1 scanning aligner and the Ultratech Model 900 1:1 stepper. It shows that a mask plate thickness of 2.2 mm offers immunity against particles up to 50-100 μm, while a pellicle standoff distance of 2.5 mm provides excellent immunity against 100-200 μm particles. For 10:1 steppers, which have a greater depth of focus, a 2.2 mm plate only provides protection against 10 μm particles on the reticle backside. A second pellicle frequently attached to the reticle backside to provide double-sided protection. A study by Flamholz[46] indicates that because of their increased depth of focus, reduction-type steppers have their images impacted by particles at somewhat greater standoff distances than predicted by the simple model of Eq. 8. Furthermore, only limited protection is afforded against extended defects, such as hairs and fibers. Flamholz concluded that in order for pellicles to adequately provide protection in such systems, all pellicle parameters must be conservatively chosen (e.g. standoff distance, focus position).

The optical transmission losses of the pellicle material (due to reflection, absorption, and scattering) affects the exposure time, and thus throughput. (In the 350-450 nm range a 2.9 μm thick nitrocellulose pellicle, with an anti-reflection coating, has an average transmission of >99%.) Nitrocellulose and mylar (another pellicle material), however, both exhibit strong absorption near 300 nm, which limits their usefulness for deep UV applications. Optical interference effects can also cause significant variations in transmission through a pellicle if the pellicle thickness exhibits even submicron nonuniformity. Fortunately, pellicles can be manufactured with thickness uniformities of better than 1%, minimizing such problems.

Masks or reticles with pellicles attached are cleaned with a DI water rinse to remove most



a)

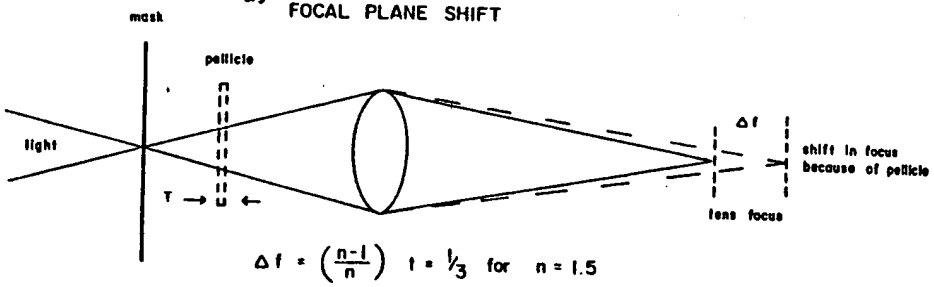


Fig. 29 (a) Photograph of a pellicle. Courtesy of EKC Technology. (b) Focal plane shift of a pellicle.

particulates. Fingerprints can be cleaned by using a mild surfactant and manual scrub. The glass (back) side of the mask is usually cleaned at the same time. Damaged pellicles can be successfully replaced if careful mask cleaning and inspection is done prior to attaching the new unit. With the exception of a few IC manufacturers, use of pellicles has become an industry standard.

Inspecting Masks and Reticles with Pellicles Attached

The process of attaching a pellicle to a defect-free mask or reticle should itself not create defects on the mask. For example, a zero defect reticle may become useless due to contamination under the pellicle. To insure that the assembly procedure has not introduced any defects, a post-pellicle inspection procedure should be performed. Van Asselt and Brooks[47] suggest a method for performing such an inspection. The mask-pellicle assembly is mounted in a projection aligner and is used to expose round, thin glass plates (glass wafers), coated with chromium and resist. The wafers are exposed, developed, etched, and stripped to produce an image suitable for inspection by transmitted light. The processed glass wafers are then inspected on an automatic mask inspection system with a special mask holder. Defects located by the inspection system that coincide in location on two or more glass wafers are attributed to defects that occurred as a result of the pellicle attachment procedure, while defects occurring in only one location can be associated with the processing of that particular wafer. The procedure can be extended to multiple-die reticles used in 1X and 5X stepping systems.

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